OUR ASTRONOMICAL COLUMN.

NEW COMET 1903*a* (GIACOBINI).—A telegram from the Kiel Centralstelle states that M. Giacobini, observing at Nice, has discovered another new comet, the position of which at 6h. 28m.·9 (Nice M.T.) on January 19 was as follows:—

$$\text{R.A.} = 22\text{h. } 57\text{m. } 48\text{s.}$$
$$\text{Dec.} = +2^\circ\ 16'\ 24''$$

that is, between the stars β and 2 Piscium, about one-third the distance from β.

The daily movements in R.A. and Dec. are + 17′ (arc) and − 12′ respectively.

COMET 1902 *d*.—No. 3838 of the *Astronomische Nachrichten* contains several sets of observations of this comet, and the elements and ephemeris given below. The latter have been calculated by Herr F. Ristenpart from the means of three observations made on December 3, three observations made on December 11 and of two observations made on December 23, all of them having been made by different observers:—

$$T = 1903 \text{ March } 25{\cdot}32785 \text{ M.T. Berlin.}$$

$$\left.\begin{array}{rrrr} & {}^\circ & ' & '' \\ \omega = & 6 & 33 & 43{\cdot}1 \\ \Omega = & 117 & 26 & 47{\cdot}3 \\ i = & 43 & 51 & 2{\cdot}1 \end{array}\right\} 1903{\cdot}0$$
$$\log q = 0{\cdot}440250$$

Ephemeris 12h. M.T. Berlin.

Date	α 1903·0 h. m. s.	δ 1903·0 ° ′ ″	log Δ
Jan. 22	6 47 20·87	+10 37 21·8	
24	6 46 3·56	+11 17 30·7	0·2791
26	6 44 49·64	+11 57 47·6	
28	6 43 39·45	+12 38 7·3	0·2816
30	6 42 33·42	+13 18 24·3	
Feb. 1	6 41 31·88	+13 58 33·9	0·2852

THE RELATION BETWEEN FACULÆ AND PROMINENCES.—In No. 11, vol. xxxi., of the *Memorie della Societa degli Spettroscopisti Italiani*, Signor Mascari submits a large number of arguments and data in order to show that there is no real connection between the solar hydrogen prominences and faculæ, but that where faculæ are attended by other outbursts, these outbursts are of the eruptive prominence type.

For instance, in 1895, the prominences had a maximum frequency at +30° to +40° and −20° to −30° (heliographic latitudes), and strong minima at ±60° to ±90° respectively, whilst the groups of faculæ showed an almost symmetrical arrangement with regard to the solar equator, having only slight maxima of frequency at +10° to +20° and ±70° to ±80°; the same relations held during 1896, and many similar cases are quoted by the writer for other years.

Again, out of two hundred and ninety-six groups of faculæ observed in 1900, only fourteen were coincident with ordinary prominences, whilst ninety-nine coincided with eruptive prominences having bases of small extent.

Signor Mascari therefore arrives at the conclusion that the hydrogen prominences, such as are commonly observed on the sun's limb, and faculæ are two distinct and completely independent phenomena.

SPECTROGRAPHIC DETERMINATION OF THE ROTATION PERIOD OF JUPITER.—Two excellent spectrograms of Jupiter, obtained by Mr. V. M. Slipher, of the Lowell Observatory, Flagstaff, Mexico, are reproduced in No. 101 of *Popular Astronomy*. No. 1 was taken in such a position that the dispersion was parallel to the equatorial diameter of the planet, whilst in No. 2 the dispersion was parallel to the polar diameter.

No. 1 shows a very distinct displacement or inclination of the lines in the planet's spectrum as compared with the lines in the lunar spectrum, which was photographed as a comparison spectrum on both sides of it. In No. 2, this displacement was non-existent. Measurements of the displacement in spectrogram No. 1 were made, and, on applying Doppler's principle to them, values for the rotation period which are well in accordance with the accepted values were obtained.

THE PHOTOGRAPHY OF STELLAR REGIONS.—In a paper recently communicated to the Vienna Academy of Sciences, Herr Egon von Oppolzer discusses the question as to how the greatest number of star images may be obtained when photographing stellar regions.

He points out that in an objective uncorrected for curvature of the focal surface, this surface is a sphere having its centre in the centre of the objective, and it will only be on the intersection curve (a circle) of this sphere and the photographic plate that the star images will be in focus, and therefore it will only be on this curve that images of the fainter stars will be obtained. The further from the curve the star image happens to fall, the greater will have to be the magnitude of the star in order that its image may be photographed.

Herr Oppolzer then establishes a relation connecting the distance of a star image from this focal circle, the radius of the focal circle and the focal length of the objective, and finally arrives at the conclusion that the formula $\delta_0 = L2/16f$ (where L = the length of the side of the square plate and f = the focal length of the objective) gives the best distance (δ_0) that the plate must be pushed in from the axial focus in order that the maximum number of stars may be photographed. Applying this formula to the Potsdam astrographic refractor, we find that the plate should have been pushed in 0·47 mm., whereas we see, from the Potsdam plates for the "Carte Celeste," that it was only pushed in 0·13 mm., and Herr Oppolzer deduces from this that an unnecessary loss, amounting to as much as 6 per cent., has occurred in the number of stars photographed (*Astrophysical Journal*, No. 5, vol. xvi.).

THE FORMATION OF PEARLS.[1]

BY far the greater number of recent writers on pearls, whether scientific or otherwise, when discussing the cause of pearl-formation, have contented themselves with recapitulating what has already been written on the subject, without attempting to verify or refute the various hypotheses that have been propounded. The question is one which has called forth speculative theories since the earliest times of which we have any records; but, with the exception of the brilliant researches of Filippi and a few of his contemporaries, theory has prevailed to the almost complete exclusion of practical investigation.

In a recent paper,[1] based upon an examination of large quantities of material comprising a number of the pearl-producing species of mollusca, I have tried to place our knowledge of the matter upon a more satisfactory basis.

By observations upon pearl-bearing examples of the common mussel, *Mytilus edulis* (which were confirmed in the case of all other species examined), I proved that the formation of the pearl takes place in exactly the same way as that of the shell, except that a true pearl is laid down in a closed sac of the shell-secreting epithelium, embedded in the subepidermal tissue of the mantle and completely cut off from the outer epithelium itself. Inside this spherical epithelial sac, the shell substance is laid down in the concentric layers that are so characteristic of the pearls, instead of in the parallel lamellæ which are found in the shell itself. Such a sac, with its contained pearl, may be compared to a human atheroma cyst.

This makes it necessary for us to draw a sharp distinction between pearls proper and blisters or pearly excrescences of the shell lining, which are secreted by the outer (shell-forming) mantle epithelium, to cover over foreign bodies that have intruded themselves between the mantle and the shell or to repair the damages done by shell-boring domiciliaries. "Concretions" are, again, distinguished from pearls as calcosphæritic bodies which have not a cuticular origin from an epithelium, but seem to arise by free crystallisation in the mantle or other tissues. The term "attached pearl" should be applied only to pearls which have become secondarily fused to the shell by absorption of the intervening tissues.

From the facts of pearl-formation, it is easy to understand why the pearl presents the special characters of the particular species of shell from which it is taken, and also why, in the same mollusc, the characters of the pearls produced are determined by the part of the mantle in which they are formed. Thus, pearls formed in the extreme mantle margin are composed mainly of periostracum, *e.g.* the leathery pearls of *Modiola modiolus*, while those which occur in the part of the mantle concerned in depositing the prismatic substance are made up of concentric layers of rod-like prisms, as in the brown or "black" pearls of the Scotch river mussel, *Margaritana margaritifera* (Fig. 1).

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[1] "On the Origin of Pearls." By Dr. H. Lyster Jameson (*Proceedings* of the Zoological Society of London, 1902, vol. i., pp. 140–166, pl. xiv–xvii.).

By far the greater part of the mantle epithelium deposits the nacre, and pearls which arise in this part of the mantle are the typical nacreous ones, to which the great majority of the marketable gems belong. Even the uncalcified substance of the hinge ligament of the shell may be represented in the pearl; for example, in the great Australian mother-of-pearl oyster, *Margaritifera maxima*, Jameson, black leathery pearls are sometimes found in the dorsal body-wall.

I next proceeded to investigate the origin of the sac in which the pearl arises, and also the nature and origin of the "nucleus" which is so often to be found in the centre of the pearl. In a great many molluscs, among which were several of the pearl-oysters proper, the remains of trematodes were found to form the nuclei, a discovery which confirmed the observations of Filippi, Möbius and others. In one or two cases, however, other parasites played the same part. By confining my attention to the common mussel, I proved that the epithelial sac, which is all-important for pearl formation, is first formed around the live trematode which enters upon a resting stage in the tissues of Mytilus. A similar sac, surrounding a trematode, was found in an example of the Ceylon pearl-oyster, *Margaritifera vulgaris*, Schumacher, which I examined. For the formation of the pearl, it is not necessary for the trematode to persist as nucleus, for it often happens that it migrates out of the sac; but the sac, caused primarily by the specific stimulation of the parasite, is essential to pearl production. In *Modiola modiolus*, and probably in some other forms, similar sacs are formed around Sporozoa.

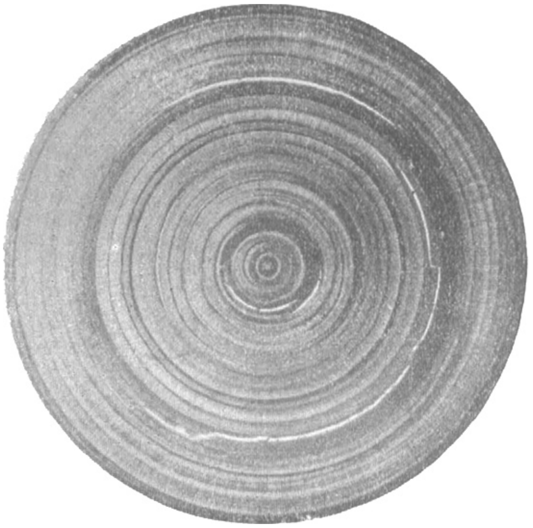

FIG. 1.—Section ground from a brown Scotch River Pearl, showing it to be composed of the Prismatic Substance, × 25.

The next subject to be investigated was the origin and life-history of the parasite that causes the pearl-sac. The common mussel was found to be the most convenient species on which to study this, and the pearl-bearing mussel-beds of Billiers, in Brittany, and Piel, in the Barrow Channel, were selected as suitable sites in which to begin the observations (Fig. 2).

The parasite, like most trematodes, passes through a regular cycle of three hosts, two of which are invertebrates and the third a vertebrate. It arises in sporocysts in the "tapestry shell," *Tapes decussatus*, and the cockle, *Cardium edule*, the former acting as first host at Billiers, the latter at Piel, where Tapes does not occur. The young tailless Cercariæ or trematode larvæ leave the mother sporocysts in the first host and migrate into the mussel.

The transmission of the parasites from Tapes to Mytilus was proved experimentally in a tank at the Brighton Aquarium. In the mussel, the parasite enters into a resting stage, in the subepidermal connective tissue, and gives rise to the epidermal sac or "epithelioma" in which the pearl arises (Fig. 3). If the parasite dies in this sac, a pearl is formed around its remains, or, if it migrates to another part of the tissues, a pearl may be developed in the empty sac.

Although it was found impossible to secure live uninfected material of the final host for experiment, it is almost certain that the adult stage of the parasite is *Distoma* (*Leucithodendrium*) *somateriae*, Lev., a worm which occurs in the intestine of the eider duck, *Somateria mollissima*, and the black duck or scoter, *Oedemia nigra*. Both these birds feed almost exclusively on mussels. A number of scoters caught or shot in the immediate vicinity of the Billiers pearl-beds were found swarming with this worm. Indeed, one example of the worm, in an immature condition, quite indistinguishable from the resting stage which occurs in Mytilus, was taken from the intestine of a scoter. Our knowledge of the life-histories of other trematodes, or "flukes" as they are popularly called, enables us to fill in the life-history of this parasite with considerable detail. The worm reaches maturity in the intestine of the scoter and eider, and the eggs pass out with the fæces. These eggs, or possibly "Miracidium" larvæ derived from them, enter Tapes or the cockle and there give rise to sporocysts, in which the young flukes or Cercariæ are formed. These larvæ, unlike typical Cercariæ, are tailless, and when they escape from Tapes reach the mussel chiefly by drifting with the tidal currents. On entering the mussel, they pierce the body wall and settle down in the subcutaneous tissues, in which they become surrounded by the pearl-sacs. If the mussel lives long enough, pearls will be formed in these sacs. If, on the other hand, a mussel containing these resting Cercariæ is eaten by an eider duck or scoter, the Cercariæ develop into the mature worms, which produce eggs, and the life cycle is repeated.

FIG. 2.—The Pearl-bearing Mussel-beds at Piel, in the Barrow Channel.

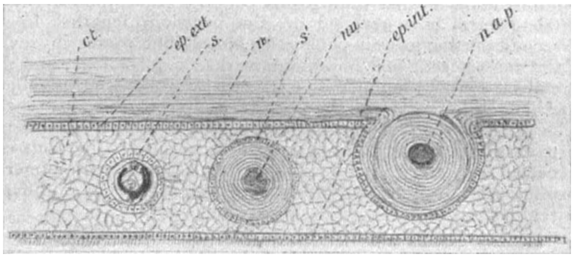

FIG. 3.—Diagrammatic section of part of the shell and mantle of Mytilus, showing a trematode in its sac, a pearl in a similar sac and a secondarily attached pearl; *n.*, nacreous substance of the shell; *ep ext.*, external nacre-secreting epithelium of the mantle; *c.t.*, connective tissue; *s.*, sac containing live trematode; *s'*, sac containing pearl; *nu.*, nucleus of pearl; note also the sac of an "attached" pearl, which has become continuous with the external epithelium of the mantle; *n.a.p.*, nucleus of the attached pearl; *ep. int.*, internal ciliated epithelium of mantle, which lines the branchial cavity.

As an economic result of these investigations, it would seem that the artificial production of marketable pearls in large quantities should present no great difficulties, if the conditions essential to pearl production in the particular cases be intelligently investigated. The fact that trematodes have been ascertained to be *at least* one cause of pearl formation in several of the molluscs that produce the marketable gems gives us every reason to hope that, by learning the life-histories of these parasites, we may be able to infect any number of pearl-oysters or pearl-mussels to any desired extent, without any operation on the individual molluscs, by simply placing them in the proper surroundings, in company with infected examples of the first host. Once infected, the molluscs could be bedded out on suitable grounds, and left to care for themselves, until the pearls formed in them were of marketable size.

These observations show the futility of the proposal that has so often been made, viz., that young pearl-oysters should be transferred from their native grounds to more accessible inshore waters, as it must obviously be the first object of the scientific expert, before laying down the beds of young pearl-oysters, to assure himself either that they are already infected or that the conditions essential to speedy infection are present on the grounds to which the oysters are to be transplanted.

H. LYSTER JAMESON.

THE MOVEMENTS OF GLACIERS.

THE study of the movements of glaciers is, we are glad to say, being steadily pursued, judging from the two reports which are to hand. The first is a publication of the International Commission on Glaciers, and is the seventh report (1901) prepared by Dr. Finsterwalder and M. E. Muret (extract from *Archives des Sciences physiques et naturelles*, t. xiv., 1902). The report is divided into five parts, dealing with observations made in the Alps of Central Europe, Scandinavia, Spitsbergen and Greenland, Russia and, lastly, the United States. In each case, a brief summary is given of the results of the 1891 observations published during the past year, and most of these show that, on the whole, the glaciers have decreased in length.

The second publication contains, not only a report on the variations of French glaciers from 1900 to 1901, presented to the French Commission by M. W. Kilian, but a review of glaciology, by M. Charles Rabot (extract from the *Annuaire du Club Alpin Français*, vol. xxviii., 1901). Detailed observations are given at some length, and in a few instances reproductions of photographs of glaciers accompany the text. The observations indicate that during this period of time the majority of the glaciers have recoiled or diminished in length. In the second portion of this publication, M. Rabot passes in review the most recent and important works on glaciology, and thus collects a useful number of references to works on this subject. After a brief survey of the physical and geological phenomena, he makes a *résumé* of the explorations of glaciers in different parts of the earth, pointing out the more interesting facts connected with them, and finally gives an account, with numerous references, of the variations of the length of glaciers in different regions.

THE SCIENCE OF ASTRONOMY.[1]

I TAKE for the subject of my address the science of astronomy, and propose to give a brief historical sketch of it, to consider its future development and to speak of the influence of the sciences on civilisation.

The science of astronomy is so closely connected with the affairs of life, and is brought into use so continuously and in such a systematic manner, that most people never think of the long labour that has been necessary to bring this science to its present condition. In the early times, it was useful to the legislator and the priest for keeping records, the times of public ceremonies and of religious festivals. It slowly grew into the form of a science and became able to make predictions with some certainty. This was many centuries ago. Hipparchus, who lived 150 B C., knew the periods of the six ancient planets with considerable accuracy. His periods are :—

	Period. d.	Error × 100. Period. d.
Mercury	87·9698	+0·0007
Venus	224·7028	+0·0009
Earth	365·2599	+0·0010
Mars	686·9785	−0·0002
Jupiter	4332·3192	−0·0061
Saturn	10758·3222	−0·0083

These results indicate that more than two thousand years ago there existed recorded observations of astronomy. Hipparchus appears to have been one of those clear-headed men who deduce results from observations with good judgment. There was a time when those ancient Greek astronomers had conceived the heliocentric motions of the planets, but this true theory was set aside by the ingenious Ptolemy, who assumed the earth as the centre of motion, and explained the apparent motions of the planets by epicycles so well that his theory became the one adopted in the schools of Europe during fourteen centuries. The Ptolemaic theory flattered the egotism of men by making the earth the centre of motion and it corresponded well with old legends and myths, so that it became inwoven with the literature, art and religion of those times. Dante's construction of Hell, Purgatory and Paradise is derived from the Ptolemaic theory of the universe. His ponderous arrangement of ten divisions of Paradise, with ten Purgatories and ten Hells, is said by some critics to furnish convenient places for Dante to put away his friends and his enemies, but it is all derived from the prevailing astronomy. Similar notions will be found in Milton, but modified by the ideas of Copernicus, which Milton had learned in Italy. The Copernican theory won its way slowly, but surely, because it is the system of nature, and all discoveries in theory and practical astronomy helped to show its truth. Kepler's discoveries in astronomy, Galileo's discovery of the laws of motion and Newton's discovery of the law of gravitation put the Copernican theory on a solid foundation. Yet it was many years before the new theories were fully accepted. Dr. Johnson thought persecution a good thing, since it weeds out false men and false theories. The Copernican and Newtonian theories have stood the test of observation and criticism, and they now form the adopted system of astronomy.

The laws of motion, together with the law of gravitation, enable the astronomer to form the equations of motion for the bodies of our solar system; it remains to solve these equations, to correct the orbits, and to form tables of the sun, moon and the planets. This work was begun more than a century ago, and it has been repeated for the principal planets several times, so that now we have good tables of these bodies. In the case of the principal planets, the labour of determining their orbits was facilitated by the approximate orbits handed down to us by the ancient astronomers, and also by the peculiar conditions of these orbits. For the most part, the orbits are nearly circular; the planets move nearly in the same plane, and their motions are in the same direction. These are the conditions Laplace used as the foundation of the nebular hypothesis. With approximate values of the periods and motions, and under the other favouring conditions, it was not difficult to form tables of the planets. However, the general problem of determining an orbit from three observations, which furnish the necessary and sufficient data, was not solved until about a century ago. The orbits of comets were first calculated with some precision. Attention was called to these bodies by their threatening aspects and by the terror they inspired among people. It was, therefore, a happy duty of the astronomers to show that the comets also move in orbits around the sun and are subject to the same laws as the planets. This work was easier, because the comets move nearly in parabolas, which are the simplest of the conic sections. Still, the general problem of finding the six elements of an orbit from the six data given by three observations remained to be solved. The solution was given by Gauss a century ago in a very elegant manner. His book is a model, and one of the best ever written on theoretical astronomy. No better experience can be had for a student than to come in contact with such a book and with such an author. The solution of Laplace for the orbit of a comet is general, but demands more labour of computing than the method of Olbers, as arranged by Gauss. It is said by some writers that the method of Laplace is to be preferred because more than three observations can be used. In fact, this is necessary in order to get good values o.

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[1] Address delivered by Prof. Asaph Hall, on December 29, 1902, as president of the American Association for the Advancement of Science, Washington meeting.